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(54) METHOD FOR PRODUCING BONDING SOI WAFER AND BONDING SOI WAFER

(57)Abstract:

PROBLEM TO BE SOLVED: To obtain an SOI wafer including a high quality SOI layer having excellent surface roughness and reduced crystal defect with high productivity, high production yield and low cost.

SOLUTION: In the method for producing a bonding SOI wafer, a single crystal silicon rod is grown by Czochralski method and sliced to obtain a single crystal silicon wafer. The single crystal silicon wafer is heat treated at 1100-1300°C for 1 min or longer in nonoxidizing atmosphere and further heat treated continuously at 700-1300°C for 1 min or longer in oxidizing atmosphere without cooling down to 700°C or below to produce a single crystal silicon wafer having a silicon oxide film formed on the surface which is then employed as a bond wafer for forming a bonding SOI wafer. A bonding SOI wafer produced by that method is also include in the invention.

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CLAIMS

[Claim(s)]
[Claim 1] In the manufacture approach of the lamination SOI wafer which thin-film-izes said bond wafer after sticking a bond wafer and a base wafer through an oxide film After raising a silicon single crystal rod, slicing this single crystal rod and processing it into a silicon single crystal wafer with the Czochrlski method, Heat treatment with a temperature of 1100-1300 degrees C is added to this silicon single crystal wafer 1 minute or more under a non-oxidizing atmosphere. The silicon single crystal wafer with which silicon oxide was formed in the front face by adding heat treatment with a temperature of 700-1300 degrees C 1 minute or more by the oxidizing atmosphere continuously, without cooling in temperature of less than 700 degrees C is produced. The manufacture approach of the lamination SOI wafer characterized by using this wafer as said bond wafer.
[Claim 2] In the manufacture approach of the lamination SOI wafer which thin-film-izes said bond wafer after sticking a bond wafer and a base wafer through an oxide film After raising a silicon single crystal rod, slicing this single crystal rod and processing it into a silicon single crystal wafer with the Czochrlski method, Heat treatment with a temperature of 1100-1300 degrees C is added to this silicon single crystal wafer 1 minute or more under a non-oxidizing atmosphere. The silicon single crystal wafer with which heat treatment with a temperature of 700-1300 degrees C was continuously added 1 minute or more by the oxidizing atmosphere, and silicon oxide was formed in the front face, without cooling in temperature of less than 700 degrees C is produced. The wafer in which poured either [at least] a hydrogen ion or rare gas ion into from the front face through the silicon oxide of this wafer, and the ion-implantation layer was made to form is used as said bond wafer. The manufacture approach of the lamination SOI wafer characterized by making it stick with said base wafer through the silicon oxide of this bond wafer, adding heat treatment subsequently, and exfoliating in said ion-implantation layer.
[Claim 3] The manufacture approach of the lamination SOI wafer characterized by using the bond wafer which exfoliated in the ion-implantation layer by the manufacture approach of the lamination SOI wafer indicated by claim 2 as a new bond wafer.
[Claim 4] The manufacture approach of the lamination SOI wafer characterized by using the bond wafer which exfoliated in the ion-implantation layer by the manufacture approach of the lamination SOI wafer indicated by claim 2 as a new base wafer.
[Claim 5] The manufacture approach of the lamination SOI wafer indicated in any 1 term of claim 1 to which said non-oxidizing atmosphere is characterized by being the mixed gas of an argon, nitrogen, or an argon and nitrogen thru/or claim 4.
[Claim 6] The manufacture approach of the lamination SOI wafer indicated in any 1 term of claim 1 characterized by said oxidizing atmosphere being an ambient atmosphere containing a steam thru/or claim 5.
[Claim 7] The manufacture approach of the lamination SOI wafer indicated in any 1 term of claim 1 to which said oxidizing atmosphere is characterized by being a mixed-gas ambient atmosphere with a desiccation oxygen ambient atmosphere or desiccation oxygen, an argon, or nitrogen thru/or claim 5.
[Claim 8] The manufacture approach of the lamination SOI wafer indicated in any 1 term of claim 1

characterized by setting to 20-100nm oxide-film thickness formed of heat treatment under said oxidizing atmosphere thru/or claim 7.

[Claim 9] The manufacture approach of the lamination SOI wafer indicated in any 1 term of claim 1 characterized by forming an oxide film in the wafer front face before performing heat treatment under said non-oxidizing atmosphere beforehand thru/or claim 8.

[Claim 10] The manufacture approach of the lamination SOI wafer indicated to claim 9 characterized by setting thickness of the thermal oxidation film on the front face of a wafer after heat treatment under said oxidizing atmosphere to 300nm or more.

[Claim 11] The manufacture approach of the lamination SOI wafer indicated in any 1 term of claim 1 characterized by raising controlling the cooling rate in 1150-1080 degrees C of this single crystal rod 2.3 degrees C / more than min in case a silicon single crystal rod is raised with said Czochrlski method thru/or claim 10.

[Claim 12] The manufacture approach of the lamination SOI wafer indicated in any 1 term of claim 1 characterized by raising the silicon single crystal rod which doped nitrogen in case a silicon single crystal rod is raised with said Czochrlski method thru/or claim 11.

[Claim 13] The manufacture approach of the lamination SOI wafer indicated to claim 12 characterized by making into 1x1010 - 5x1015 atoms/cm3 nitrogen concentration doped on this single crystal rod in case the silicon single crystal rod which doped nitrogen with said Czochrlski method is raised.

[Claim 14] The manufacture approach of the lamination SOI wafer indicated in any 1 term of claim 1 characterized by setting to 18 or less ppmas the oxygen density contained on this single crystal rod in case a silicon single crystal rod is raised with said Czochrlski method thru/or claim 13.

[Claim 15] The lamination SOI wafer manufactured by the approach indicated to claim 1 thru/or claim 14.

[Claim 16] The lamination SOI wafer with which a SOI layer consists of a CZ silicon single crystal wafer, and SOI thickness is a SOI wafer 5 micrometers or less, it migrates to all the fields of the depth direction of a SOI layer, and magnitude is characterized by COP 0.09 micrometers or more being two or less [1.3 //cm].

[Translation done.]

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the manufacture approach of a lamination SOI wafer with very few crystal defects near a front face and the front face, and a lamination SOI wafer.
[0002]
[Description of the Prior Art] SOI (Silicon On Insulator) has an embedding oxide film (BOX:BuriedOXide) as an insulator layer directly under [used as a device production field] a silicon layer, and is expected as a silicon ingredient of power saving and a high-speed device. Although there is a lamination method as one of the SOI wafer manufacture approaches, this is the approach of thin-film-izing lamination and a bond wafer for two silicon single crystal wafers through an oxide film as a bond wafer (substrate used as the SOI layer by which a device is produced), and a base wafer (substrate which supports a SOI layer), and forming SOI structure. Although this approach is excellent in the crystallinity of a SOI layer and has the advantage that the insulation of BOX is high, on the other hand, the fault that the quality of a SOI layer is greatly influenced by the quality of this bond wafer also exists.
[0003] In the silicon wafer produced with the Czochrlski method (CZ process), it is specifically known that minute crystal defects (Grown-in defect), such as COP (Crystal Originated Particles) which is a void mold defect, exist, and these have a bad influence on device properties including an oxide film proof-pressure property. In order to solve this problem, it is known by using for CZ wafer the wafer which gave annealing in a hydrogen ambient atmosphere, and the epitaxial wafer in which the epitaxial layer was formed, as a substrate used for a bond wafer that the defect observed will decrease (refer to JP,9-22993,A and JP,9-260619,A). However, by these approaches, two heat treatments, heat treatment of hydrogen annealing or epitaxial growth and oxide-film formation heat treatment for forming the embedding oxide film of a SOI wafer, are needed, and the problem of the fall of the increase and the throughput of cost etc. exists.
[0004] Moreover, since in the case of an epitaxial wafer Hayes (field dry area) occurs on an epitaxial layer front face, or the projection called the mound is formed in it and these cause ill cohesion of strands at the time of lamination, the time and effort of joining together once it grinds an epitaxial layer front face may be needed.
[0005] That a crystal defect decreases by performing hydrogen annealing on the other hand In the SOI front face at the time of producing the SOI wafer which has the thickness beyond this, since it is restricted to the pole surface layer (about 0.5 micrometers) If the measures of adding hydrogen annealing further were not taken after producing the SOI wafer since the field where the crystal defect is not reduced would be exposed, the crystal defect covering the whole SOI layer was not able to be reduced. Furthermore, annealing using hydrogen always etches a quartz tube, the boat made from SiC, etc., and contamination of a metal impurity etc. may take place from there.
[0006] Furthermore, although insurance needed to be secured by take out a wafer after heat-treat in a hydrogen ambient atmosphere, and nitrogen gas permuted the inside of a heat treating furnace, the oxygen and the moisture of a minute amount which be contain in nitrogen gas etched the wafer front

face locally, and worsened surface roughness, such as Hayes, and the trouble of become the cause that these association at the time of lamination be poor also had them.
[0007] Moreover, by recently, if a crystal is pulled up controlling strictly the growth rate at the time of single crystal growth, and the temperature gradient of a solid-liquid interface by the CZ process, it is reported that CZ wafer with which the Grown-in defect was reduced very much is made. Although it can guess easily that the defect of a SOI layer can produce few SOI wafers if such a wafer is used for a bond wafer, pulling up a crystal on such very severe growth conditions actually leads to the fall of a manufacture yield with a natural thing, and it brings about a cost rise great as a result.
[0008] On the other hand, although a COP defect which is looked at by CZ single crystal is free, the diameter of 150mm of an FZ crystal producible on current commercial level is a limit, and although no less than 200mm is possible, on experiment level, it is not [to the wafer of diameters of macrostomia, such as 300mm of future, and 400mm,] in prospect, if it is the single crystal produced by the FZ method.
[0009]
[Problem(s) to be Solved by the Invention] This invention sets it as the main purpose to obtain the SOI wafer which has the SOI layer of high quality with few crystal defects by the sex from Takao, the high yield, and low cost by having been made in view of such a trouble and using the wafer which decreases or extinguished effectively the Grown-in defect of the surface section of the silicon single crystal wafer produced by the CZ process by heat treatment as a bond wafer of a lamination wafer.
[0010]
[Means for Solving the Problem] In the manufacture approach of the lamination SOI wafer which thin-film-izes said bond wafer after this invention which solves the above-mentioned technical problem sticks a bond wafer and a base wafer through an oxide film After raising a silicon single crystal rod, slicing this single crystal rod and processing it into a silicon single crystal wafer with the Czochrlski method, Heat treatment with a temperature of 1100-1300 degrees C is added to this silicon single crystal wafer 1 minute or more under a non-oxidizing atmosphere. The silicon single crystal wafer with which silicon oxide was formed in the front face by adding heat treatment with a temperature of 700-1300 degrees C 1 minute or more by the oxidizing atmosphere continuously, without cooling in temperature of less than 700 degrees C is produced. It is the manufacture approach of the lamination SOI wafer characterized by using this wafer as said bond wafer (claim 1).
[0011] In the manufacture approach of a lamination SOI wafer, to thus, the wafer obtained by the Czochrlski method Add heat treatment with a temperature of 1100-1300 degrees C 1 minute or more under a non-oxidizing atmosphere, and heat treatment with a temperature of 700-1300 degrees C is continuously added 1 minute or more by the oxidizing atmosphere, without cooling in temperature of less than 700 degrees C. If the silicon single crystal wafer with which silicon oxide was formed in the front face is produced and this silicon single crystal wafer is used as a bond wafer Since the silicon single crystal wafer of the high quality which extinguishes or decreased the Grown-in defect of the wafer surface section harmful to semiconductor device production for a short time can be used as a bond wafer, The SOI wafer which has the SOI layer of high quality with few crystal defects can be obtained by the sex from Takao, the high yield, and low cost.
[0012] Moreover, after this invention sticks a bond wafer and a base wafer through an oxide film, it is set to the manufacture approach of the lamination SOI wafer which thin-film-izes said bond wafer. After raising a silicon single crystal rod, slicing this single crystal rod and processing it into a silicon single crystal wafer with the Czochrlski method, Heat treatment with a temperature of 1100-1300 degrees C is added to this silicon single crystal wafer 1 minute or more under a non-oxidizing atmosphere. The silicon single crystal wafer with which heat treatment with a temperature of 700-1300 degrees C was continuously added 1 minute or more by the oxidizing atmosphere, and silicon oxide was formed in the front face, without cooling in temperature of less than 700 degrees C is produced. The wafer in which poured either [at least] a hydrogen ion or rare gas ion into from the front face through the silicon oxide of this wafer, and the ion-implantation layer was made to form is used as said bond wafer. It is the manufacture approach of the lamination SOI wafer characterized by making it stick with said base wafer

through the silicon oxide of this bond wafer, adding heat treatment subsequently, and exfoliating in said ion-implantation layer (claim 2).

[0013] In the manufacture approach of a lamination SOI wafer, to thus, the wafer obtained by the Czochrlski method Add heat treatment with a temperature of 1100-1300 degrees C 1 minute or more under a non-oxidizing atmosphere, and heat treatment with a temperature of 700-1300 degrees C is continuously added 1 minute or more by the oxidizing atmosphere, without cooling in temperature of less than 700 degrees C. The silicon single crystal wafer with which silicon oxide was formed in the front face is produced. The wafer in which poured the hydrogen ion etc. into from the front face through the silicon oxide of this wafer, and the ion-implantation layer was made to form is used as said bond wafer. If the approach (the so-called ion-implantation exfoliating method) stick with said base wafer through the silicon oxide of this bond wafer, subsequently adds heat treatment, and it is made to exfoliate in said ion-implantation layer is used In addition to the ability to use the silicon single crystal wafer of high quality as a bond wafer, the surface state of the SOI wafer after exfoliation is also good, and the SOI wafer excellent in the thickness homogeneity of a SOI layer can be manufactured by the comparatively easy approach.

[0014] In this case, the bond wafer which exfoliated in the ion-implantation layer by the manufacture approach of the lamination SOI wafer of above-mentioned this invention can be used as a new bond wafer (claim 3).

[0015] Thus, the bond wafer which exfoliated in the ion-implantation layer by the manufacture approach of the lamination SOI wafer of this invention Since the thin film which the Grown-in defect is extinguished to the field which reaches from a front face by having added heat treatment more than a depth of 5 micrometers - about 10 micrometers or it, and moreover exfoliates in an ion-implantation layer is about 1 micrometer even if it is thick Even if it is the bond wafer after the thin film exfoliated, it has the defect-free (low defect) field of sufficient depth. Therefore, in order to reuse this wafer, even if it grinds a front face If a bond wafer is thin-film-ized and a SOI wafer is produced after sufficient defect-free field's remaining and sticking with a base wafer through an oxide film, using this as a new bond wafer It is not necessary to add again heat treatment for extinguishing a Grown-in defect to the bond wafer in front of lamination, and the lamination SOI wafer of high quality can be manufactured efficiently.

[0016] Moreover, the bond wafer which exfoliated in the ion-implantation layer by the manufacture approach of the lamination SOI wafer of above-mentioned this invention in this case can be used as a new base wafer (claim 4).

[0017] The oxygen sludge may be generated in large quantities under the effect of heat treatment inside (bulk section) rather than the defect-free field of the bond wafer front face after the thin film exfoliated. In such a case, if a bond wafer is thin-film-ized and a SOI wafer is produced after sticking with a bond wafer through an oxide film, using this wafer as a new base wafer, the high lamination SOI wafer of gettering capacity, such as a heavy-metal impurity, can be obtained. In this case, though the oxygen sludge is generated in large quantities in the bulk section, since it is a defect-free field near the front face like the above-mentioned, an oxygen sludge is not exposed to a base wafer front face, and it also has the advantage of not having a bad influence on lamination with a bond wafer.

[0018] In this case, it is desirable that said non-oxidizing atmosphere is the mixed gas of an argon, nitrogen, or an argon and nitrogen (claim 5). The mixed-gas ambient atmosphere of these argons, nitrogen, or an argon and nitrogen is easy handling, and it is because there is a cheap advantage.

[0019] Moreover, it shall be the ambient atmosphere in which said oxidizing atmosphere contains a steam in this case (claim 6). Thus, since the ambient atmosphere which includes said oxidizing atmosphere for a steam, then the oxidation rate are quick, the silicon between grids can be poured in very efficiently in a short time, and a defect can be extinguished. Moreover, since the oxide film formed in a bond wafer front face becomes comparatively thick, it is suitable for the application which manufactures a SOI wafer with the thick thickness of BOX.

[0020] In this case, said oxidizing atmosphere shall be a mixed-gas ambient atmosphere with a desiccation oxygen ambient atmosphere or desiccation oxygen, an argon, or nitrogen (claim 7). Thus, if

said oxidizing atmosphere is a mixed-gas ambient atmosphere with a desiccation oxygen ambient atmosphere or desiccation oxygen, an argon, or nitrogen, since the growth rate of an oxide film is slow and oxidation thickness formed in a bond wafer front face after heat treatment can be made thin, it is suitable for the application which manufactures a SOI wafer with the thin thickness of BOX.

[0021] Moreover, it is desirable to set to 20-100nm oxide-film thickness formed of heat treatment under said oxidizing atmosphere (claim 8). Thus, if the oxide film thickness formed of heat treatment in said oxidizing quality ambient atmosphere is 20nm or more, COP of the bond wafer surface section is fully removable. Moreover, even when 100nm or less, then the formed oxide film need to be removed, time amount which the process takes can be shortened. Furthermore, since the absolute value of the variation within a field of oxide film thickness becomes small in manufacturing a SOI wafer using said ion-implantation exfoliating method, there is also an advantage that the thickness homogeneity of a SOI layer becomes good.

[0022] Moreover, an oxide film may be beforehand formed in the wafer front face before performing heat treatment under said non-oxidizing atmosphere (claim 9). If such an oxide film is formed, a wafer front face can be protected from ****** by formation and etching of the heat nitride on the front face of a wafer by heat treatment. Therefore, the ill cohesion of strands at the time of lamination can be prevented.

[0023] Furthermore, it is desirable to set thickness of the thermal oxidation film on the front face of a wafer after heat treatment under said oxidizing atmosphere to 300nm or more in this case (claim 10). Thus, since COP on the front face of a wafer can be extinguished according to the reflow phenomenon of the silicon oxide at the time of oxide-film growth when an oxide film is beforehand formed in the wafer front face before performing heat treatment under a non-oxidizing atmosphere by growing up the thermal oxidation film with a thickness of 300nm or more by oxidation heat treatment under an oxidizing atmosphere, COP on the front face of a wafer can be extinguished more certainly.

[0024] Moreover, in case a silicon single crystal rod is raised with said Czochrlski method, it is desirable to raise controlling the cooling rate in 1150-1080 degrees C of this single crystal rod 2.3 degrees C / more than min (claim 11). Thus, if it raises controlling the cooling rate in 1150-1080 degrees C of a single crystal rod 2.3 degrees C / more than min in case a silicon single crystal rod is raised with the Czochrlski method, the size of a Grown-in defect becomes small, and since heat treatment described above to this is added, the Grown-in defect of the wafer surface section can be extinguished or decreased more effectively. Therefore, the SOI wafer which has the SOI layer of high quality more can be obtained by the sex from Takao.

[0025] Moreover, in case a silicon single crystal rod is raised with said Czochrlski method in this case, it is desirable to raise the silicon single crystal rod which doped nitrogen (claim 12). Thus, if the silicon single crystal rod which doped nitrogen is raised in case a silicon single crystal rod is raised with the Czochrlski method, since the size of a Grown-in defect will decrease further and heat treatment will be added to this by doping nitrogen, the Grown-in defect of the wafer surface section can be extinguished or decreased more effectively. Therefore, the SOI wafer which has the SOI layer of high quality more can be obtained by the sex from Takao.

[0026] In this case, in case the silicon single crystal rod which doped nitrogen with said Czochrlski method is raised, it is desirable to make into 1x1010 - 5x1015 atoms/cm3 nitrogen concentration doped on this single crystal rod (claim 13). This is because it is desirable to make it three or less 5x1015 atoms/cm in order to make it it not become the hindrance of a desirable thing and single-crystal-izing of a silicon single crystal to make it three or more 1x1010 atoms/cm in order to fully control growth of a Grown-in defect.

[0027] Furthermore, in case a silicon single crystal rod is raised with said Czochrlski method, it is desirable to make below into 18ppma(s) (JEIDA: Japan Electronic Industry Development Association specification) the oxygen density contained on this single crystal rod (claim 14). Thus, growth of hypoxia, then a crystal defect can be controlled further, and formation of the oxygen sludge in a surface layer can also be prevented.

[0028] And COP 0.09 micrometers or more is the lamination SOI wafer whose magnitude for example,

a SOI layer consists of a CZ silicon single crystal wafer, the lamination SOI wafer (claim 15) manufactured by the manufacture approach of this invention is a SOI wafer 5 micrometers or less, SOI thickness crosses it to all the fields of the depth direction of a SOI layer, and is two or less [1.3 //cm] (claim 16). Thus, even if SOI layer membrane thickness is a thing 0.5 micrometers or more, the lamination SOI wafer of this invention can be crossed to all the fields of the depth direction of a SOI layer, and COP can use it as very few SOI wafers. Furthermore, the SOI wafer of this invention does not need to give hydrogen annealing after SOI wafer production etc., and its productivity is also high.

[0029] Hereafter, although this invention is explained further in full detail, this invention is not limited to these. After this invention obtains a silicon wafer with the Czochrlski method, By performing elevated-temperature heat treatment under a non-oxidizing gas especially an argon, nitrogen, or these mixed-gas ambient atmospheres, and high-temperature-oxidation heat treatment under an oxidizing atmosphere to this wafer in succession The Grown-in defect of a wafer front face and the surface section is disappeared or reduced. Based on the knowledge that it is possible to raise the surface roughness of a wafer, and by using this silicon wafer as a bond wafer of a lamination SOI wafer A header and terms and conditions are scrutinized for the ability of a SOI wafer with the outstanding SOI layer to be manufactured by the sex from Takao, and it is completed.

[0030] As mentioned above, in order to disappear or reduce the Grown-in defect of a wafer front face and the surface section, being used on the usual commercial level tends to carry out elevated-temperature heat treatment of the wafer grown up by the general rate of crystal growth of about 1.0 or more mm/min under a hydrogen ambient atmosphere, and it tends to extinguish a Grown-in defect. Although this approach was already produced commercially and was used for manufacture of an actual device, it was a problem that still carried out in the surface section (for example, 0-5 micrometers) of a wafer, and the defect remains.

[0031] The following reasons were able to be considered as this cause. Two processes are required to extinguish the Grown-in defect which is the floc of an atomic hole. That is, it is two, the dissolution process of the wall oxide film of the defect which prevents a point defect from intrinsic shifting to a Grown-in defect, and the restoration process of the Grown-in defect by the silicon between grids which follows it.

[0032] By elevated-temperature heat treatment under said hydrogen ambient atmosphere, it is thought that the dissolution of the wall oxide film of the Grown-in defect of the wafer surface section occurs efficiently according to the remarkable oxygen out-diffusion effectiveness. However, by elevated-temperature heat treatment under a hydrogen ambient atmosphere, since both the silicon between grids which is a Schottky defect, and an atomic hole are poured in from a wafer front face, restoration of the Grown-in defect by the silicon between grids cannot be caused efficiently.

[0033] Therefore, by elevated-temperature heat treatment under a hydrogen ambient atmosphere, in order for the restoration process of the Grown-in defect by the silicon between grids to become a thing covering long duration, especially for size to extinguish a Grown-in defect 150nm or more by diameter conversion, heat treatment of the elevated temperature and long duration of 5 hours or more was needed at 1200 degrees C. Under a hydrogen ambient atmosphere, this will need elevated-temperature heat treatment of long duration, and it not only reduces the productivity of a wafer remarkably, but it cannot say it as a desirable approach in a safety aspect. Furthermore, in order to perform prolonged elevated-temperature heat treatment, the precipitation-of-oxygen nucleus in a silicon single crystal wafer is also made to disappear, and there is also a trouble of also losing the gettering effectiveness of an effective heavy metal at a device process.

[0034] this invention persons solved by adding heat treatment with a temperature of 700-1300 degrees C 1 minute or more under an oxidizing atmosphere continuously, without cooling in temperature of less than 700 degrees C, after adding heat treatment with a temperature of 1100-1300 degrees C 1 minute or more under the non-oxidizing gas which does not include these problems for hydrogen beyond a lower explosive limit (about 4%) especially an argon, nitrogen, or these mixed-gas ambient atmospheres. That is, it became possible to advance the dissolution process of a defective wall oxide film efficiently by elevated-temperature heat treatment under an argon, nitrogen, or these mixed-gas ambient atmospheres,

and to also advance efficiently the restoration process of the Grown-in defect by the silicon between grids by changing to heat treatment under an oxidizing atmosphere still more nearly continuously.
[0035] It is because it is very difficult on insurance that having presupposed that the dissolution process of the wall oxide film of a defect is carried out by elevated-temperature heat treatment under the non-oxidizing gas which does not contain hydrogen beyond a lower explosive limit (about 4%) especially an argon, nitrogen, or these mixed-gas ambient atmospheres here continues after elevated-temperature heat-treating under a hydrogen ambient atmosphere, and it performs heat treatment under an oxygen ambient atmosphere. It becomes possible to carry out heat treatment of two processes to insurance continuously for the first time by using the non-oxidizing gas which does not contain hydrogen beyond a lower explosive limit (about 4%) instead of, especially an argon, nitrogen, or these mixed-gas ambient atmospheres. [a hydrogen ambient atmosphere] Moreover, since the dissolution of the wall oxide film of a Grown-in defect occurs efficiently according to the oxygen out-diffusion effectiveness like the bottom of a hydrogen ambient atmosphere also in elevated-temperature heat treatment under a non-oxidizing gas especially an argon, nitrogen, or these mixed-gas ambient atmospheres, the dissolution process of a defective wall oxide film can be efficiently advanced like the bottom of a hydrogen ambient atmosphere for a short time.
[0036] As a reason argon atmosphere has the out-diffusion effectiveness of oxygen equivalent to a hydrogen ambient atmosphere, it is thought by elevated-temperature heat treatment of 1100-1300 degrees C under argon atmosphere that it is because the natural oxidation film on the front face of a wafer sublimates as SiO gas and is removed. Moreover, in nitrogen-gas-atmosphere mind, although the out-diffusion effectiveness of oxygen is equivalent, since the surface natural oxidation film is not removed by homogeneity, it is desirable to remove the natural oxidation film in HF water solution beforehand before heat treatment. Furthermore also in the mixed ambient atmosphere of an argon and nitrogen, the out-diffusion effectiveness equivalent to a hydrogen ambient atmosphere can be acquired. In addition, in order to fully dissolve the wall oxide film of a Grown-in defect, it was presupposed that this heat treatment is carried out 1 minute or more at the temperature of 1100-1300 degrees C.
[0037] Moreover, in heat treatment under a hot nitrogen-gas-atmosphere mind, a very stable heat nitride will be formed in a silicon wafer front face, and a wafer front face may produce ****** with minute amount oxygen and moisture the case where removing the film in a subsequent process takes time and effort, and in nitrogen. Then, this invention persons found out that a wafer front face could be protected from the unnecessary film formation in nitrogen-gas-atmosphere mind, or surface rough ** by forming the protection oxide film in the wafer front face before heat treatment beforehand.
[0038] Furthermore, such a protection oxide film also has the effectiveness of preventing the heavy-metal impurity contamination diffused inside a wafer from the inside of a furnace during heat treatment while being able to protect a wafer front face from unnecessary film formation or surface rough **.
[0039] Moreover, we decided to perform heat treatment of the dissolution process of a defective wall oxide film, and the restoration process of the Grown-in defect by the silicon between grids continuously because the wall oxide film of a Grown-in defect re-grew by the fall of the temperature of a wafer and it became impossible to be unable to disappear a defect or to reduce it as a result, when not performing heat treatment of these two processes continuously. Therefore, we decided to heat-treat two processes continuously, without the wall oxide film of a Grown-in defect cooling in temperature of less than 700 degrees C which re-grows.
[0040] And in this invention, it was presupposed that the restoration process of a Grown-in defect is based on heat treatment under an oxidizing atmosphere. This is because surface rough ** and contamination can be prevented by oxidizing the front face activated by elevated-temperature heat treatment under a non-oxidizing atmosphere while being efficiently filled up with a Grown-in defect with the silicon between grids and extinguishing the Grown-in defect since an atomic hole was not poured in from the front face of a wafer and only the silicon between grids was poured in unlike the case where heat treatment under a hydrogen ambient atmosphere is continued, in heat treatment under an oxidizing atmosphere. In addition, in order that this heat treatment may be filled up with a Grown-in defect and may fully extinguish it, it is desirable to carry out 1 minute or more at 1000-1300 degrees C,

but if it is 700 degrees C or more, the effectiveness which prevents reduction of a Grown-in defect and surface rough ** can be acquired.
[0041] Here, as this oxidizing atmosphere, a mixed-gas ambient atmosphere with the ambient atmosphere containing a steam, 100% (dry O2) ambient atmosphere of desiccation oxygen or desiccation oxygen, an argon, or nitrogen etc. is applicable. in the case of the ambient atmosphere containing a steam, since the oxidation rate is quick, it is about 700 degrees C -- comparatively, also at low temperature, the silicon between grids can be poured in very efficiently in a short time, and a defect can be extinguished. Moreover, since the oxide film formed in a front face becomes comparatively thick, when the thickness of an embedding oxide film manufactures a thick SOI wafer, it is suitable.
[0042] On the other hand, since the growth rate of an oxide film is slow in the case of a mixed-gas ambient atmosphere with a desiccation oxygen ambient atmosphere or desiccation oxygen, an argon, or nitrogen, the oxide film formed after heat treatment can be made thin, and it is suitable, when HF water solution etc. needs to remove the formed oxide film, or when using said ion-implantation exfoliating method.
[0043] In addition, when a mixed-gas ambient atmosphere was used, the growth rate of an oxide film was slow, and when the oxide-film thickness formed was thin, we were anxious about the effectiveness that the silicon between grids can be poured in and a defect can be extinguished being inferior. Then, by the following experiments, this invention persons were what oxygen densities, and when forming the oxide film of how much thickness, they checked whether a defect could fully be extinguished.
[0044] argon 100% -- after annealing for 20 minutes by the mixed gas (oxygen densities 0 and 20, 30 or 50,100%) of six kinds of argons with which 1200 degrees C of oxygen densities differ under an ambient atmosphere after annealing for 40 minutes, and desiccation oxygen, the result of having ground 5 micrometers of front faces of a wafer, and having measured COP 0.09 micrometers or more was shown in drawing 9 (a) and (b), respectively. The reason ground 5 micrometers is for observing the disappearance effectiveness of COP in the wafer surface section. In drawing 9 (a), the relation between the oxygen density in an annealing ambient atmosphere and the number of COP is shown, and the relation of the oxide-film thickness and the number of COP which were formed of annealing is shown in drawing 9 (b) at it. The result of drawing 9 shows that effectiveness equivalent to 100% (about 100nm of oxide-film thickness) of desiccation oxygen will be acquired if the desiccation oxygen density in a mixed-gas ambient atmosphere is 20nm or more of oxide-film thickness formed at least about 10%.
[0045] Furthermore, by heat-treating in an oxidizing quality ambient atmosphere, after heat-treating under a non-oxidizing quality ambient atmosphere showed that there was effectiveness which prevents the contamination to the wafer from a tube or a boat to the minimum. drawing 10 -- argon 100% -- under an ambient atmosphere, each of heat treatment which anneals for 20 minutes, and heat treatment which anneals for 60 minutes 1200 degrees C at 100% [of hydrogen] and argon 100% is repeated and heat-treated by the separate tube by the mixed gas (30% of oxygen densities) of an argon and desiccation oxygen, and 1200 degrees C of transitions of the contamination level by the metal impurity in the wafer for every heat treatment are compared, after annealing for 40 minutes. Measurement of contamination level used SPV (Surface Photon Voltage) (trade name: wafer contamination monitor system) by the Semiconductor Diagnostics Inc. (SDI) company.
[0046] In annealing of only hydrogen or an argon, in order that etching of a tube or a boat may break out, it turns out that impurity level gets worse suddenly. On the other hand, by heat treatment containing annealing in an oxidizing quality ambient atmosphere, since an oxide film is formed also in a wafer front face, a boat, or a tube front face in an annealing process, a protection oxide film is always formed and it is thought that there is effectiveness which prevents the contamination from a tube or a boat to the minimum.
[0047] It is limited to the crystal defect inside the wafer which has not appeared in a silicon wafer front face that it can be made to disappear by oxidation heat treatment at such 700-1300 degrees C. That is because disappearance of a defect here is what is depended on restoration of the void mold crystal defect by impregnation of the silicon between grids from the front face by oxidization. Therefore, it is necessary to extinguish a void mold crystal defect like COP exposed to a front face by the migration of

the silicon atom on the front face of a wafer by heat treatment of the argon atmosphere before this oxidation heat treatment etc. However, if the surface-protection oxide film is formed beforehand as mentioned above, since the migration of a surface silicon atom will be controlled, disappearance of surface COP may become inadequate.

[0048] Then, this invention persons considered how to fully extinguish COP on the front face of a wafer, by setting thermal oxidation thickness on the front face of a wafer after oxidation heat treatment at said 700-1300 degrees C to 300nm or more, when a surface-protection oxide film was beforehand formed before heat treatment under a non-oxidizing atmosphere. This is because the same effectiveness as the configuration of surface COP having become smooth and having extinguished COP substantially can be acquired in the process in which the thermal oxidation film will be grown up after oxidation heat treatment if the thermal oxidation thickness on the front face of a wafer is 300nm or more. Moreover, the average size of COP on the front face of a wafer is 100-200nm, and it is because it is enough to incorporate and extinguish COP in an oxide film if an oxide film with a thickness of about 300nm is formed. In addition, the oxide film formed by this oxidation heat treatment is removable with HF water solution etc.

[0049] How to control the cooling rate in 1150-1080 degrees C of a single crystal rod furthermore, 2.3 degrees C / more than min, in case this invention persons raise a silicon single crystal rod with the Czochrlski method, By and the method of raising the silicon single crystal rod which doped nitrogen, in case a single crystal rod is raised By producing a silicon wafer with few Grown-in defects in which size is large, by the sex from Takao, and presenting non-oxidizing quality heat treatment and oxidizing quality heat treatment of an argon etc. of above-mentioned this invention It discovered raising the effectiveness of furthermore extinguishing and decreasing the Grown-in defect of a silicon single crystal wafer.

[0050] That is, the Grown-in defect is said for the condensation to take place by the 1150-1080-degree C temperature zone under crystal raising. Therefore, by making quick the cooling rate in a 1150-1080-degree C temperature zone with more than 2.3 degrees C / min, and shortening residence time, it becomes possible to control the size and the number of Grown-in defects.

[0051] Moreover, if nitrogen is doped in a silicon single crystal, it is pointed out that condensation of the atomic hole in silicon is controlled (T. 3 Abe and H.Takeno, Mat.Res.Soc.Symp.Proc.Vol.262, 1992). It is thought that this effectiveness is for the condensation process of an atomic hole to shift to ununiformity nucleation from homogeneity nucleation. Therefore, if nitrogen is doped in case a silicon single crystal is raised by the CZ process, the small silicon single crystal and this small of a Grown-in defect can be processed, and a silicon single crystal wafer can be obtained. And according to this approach, like said conventional method, since it is not necessary to necessarily low-speed-ize the rate of crystal growth, a silicon single crystal wafer can be obtained by the sex from Takao.

[0052] Moreover, in case a silicon single crystal rod is raised with the Czochrlski method, it is desirable to set to 18 or less ppmas the oxygen density contained on a single crystal rod. This is because such hypoxia concentration, then growth of a crystal defect can be controlled further and formation of the oxygen sludge in the wafer surface section can be prevented. Since precipitation of oxygen is promoted when nitrogen is especially doped to a single crystal, it is desirable by considering as the above-mentioned oxygen density to prevent formation of the oxygen sludge in the wafer surface section.

[0053]

[Embodiment of the Invention] What is necessary is just to specifically change the raising rate of a crystal in this invention, in order to control the size and the number of Grown-in defects with a cooling rate in the Czochrlski method. For example, when a single crystal is pulled up when a certain specific raising equipment is used, and it is made rate 1.8 mm/min, compared with the case where it pulls up by 1.0 mm/min with the same equipment, a cooling rate becomes high. Even if it changes arrangement of the interior material of a furnace called the hot zone of raising equipment, structure, etc. as the other approaches, it is possible to adjust the cooling rate in 1150-1080 degrees C.

[0054] Moreover, the magnitude of a Grown-in defect is controllable also by doping impurity nitrogen during the single crystal growth by the Czochrlski method. In this case, what is necessary is to just be

based on a well-known approach which is indicated by JP,60-251190,A, in order to raise the silicon single crystal rod which doped nitrogen.
[0055] That is, before raising a silicon single crystal rod, nitrogen can be doped during a raising crystal by putting in the nitride in the quartz crucible beforehand, throwing in a nitride in silicon melt, or making a controlled atmosphere into the ambient atmosphere containing nitrogen etc. Under the present circumstances, the amount of dopes under crystal is controllable by adjusting concentration or installation time of the amount of a nitride, or nitrogen gas etc. Thus, in case a single crystal rod is raised with the Czochrlski method, condensation of the Grown-in defect introduced into crystal growth can be controlled by doping nitrogen.
[0056] If nitrogen is doped in a silicon single crystal, it will be thought that the reason the crystal defect introduced into silicon becomes small is for the condensation process of an atomic hole to shift to ununiformity nucleation from homogeneity nucleation as above-mentioned. Therefore, the concentration of the nitrogen to dope is good to consider as three or more 5x1013 atoms/cm preferably [making it three or more 1x1010 atoms/cm which fully causes ununiformity nucleation], and more preferably. Condensation of a crystal defect can fully be controlled by this. If nitrogen concentration exceeds 5x1015 atoms/cm3 which is a solid-solution limit community in a silicon single crystal, since the single-crystal-izing of a silicon single crystal itself will be checked on the other hand, it is made not to exceed this concentration.
[0057] Moreover, in this invention, although it is desirable to set to 18 or less ppmas the oxygen density contained on a single crystal rod in case a silicon single crystal rod is raised with the Czochrlski method, the method of reducing the oxygen density contained on a single crystal rod in the above-mentioned range should just be based on the approach commonly used from the former. For example, it can consider as the above-mentioned oxygen density range easily with means, such as temperature distribution of reduction of a crucible rotational frequency, the increment in an introductory quantity of gas flow, the fall of the ambient pressure force, and silicon melt, and adjustment of the convection current.
[0058] In this way, in the Czochrlski method, the silicon single crystal rod with which the size and the number of Grown-in defects were reduced is obtained. After slicing this according to the usual approach with cutting equipments, such as an inner circumference cutting-edge slicer or a wire saw, it is processed into a silicon single crystal wafer through processes, such as beveling, wrapping, etching, and polish. of course -- ** these processes remain for having carried out instantiation listing, in addition may have various processes, such as washing, -- modification of the order of a process part -- according to the purposes, such as an abbreviation, modification use of the process can be carried out suitably.
[0059] In this way, CZ silicon single crystal wafer which turns into a bond wafer in this invention is obtained. Hereafter, how to manufacture the SOI wafer of this invention using this CZ silicon wafer is explained. Drawing 1 (A) - (E) is the flow Fig. having shown an example like the manufacture line of the lamination SOI wafer of this invention, and drawing 2 is drawing having shown the outline of heat treatment added to the silicon single crystal wafer which turns into a bond wafer in front of lamination.
[0060] First, heat treatment which consists of two-step steps as shown in drawing 1 (B), (C), and drawing 2 is performed to CZ silicon single crystal wafer 5 used as a bond wafer. first -- as the first step -- Ar gas 100% -- in a 1100 to 1300 degrees C temperature region, annealing for 1 minute or more is performed under an ambient atmosphere, out-diffusion of the oxygen under crystal is carried out, and the oxide-film wall of a void defect is dissolved. The low defective layer 3 is formed in the silicon single crystal wafer 5 (drawing 1 (B), drawing 2). Then, without lowering to the temperature of less than 700 degrees C, by performing annealing for 1 minute or more in a 700 to 1300 degrees C temperature region under an oxidizing atmosphere continuously, and forming an oxide film 4, from Si/SiO2 interface, the silicon between grids is poured in, a void defect is extinguished till the deeper place under crystal, and the low defective layer 3 is expanded (drawing 1 (C), drawing 2). By this approach, COP can be effectively extinguished from a front face to a depth of 5 micrometers - about 10 micrometers, or more than it. In addition, in order to perform this heat treatment, it is available even if it is the heat treating furnace of what kind of gestalt marketed widely, if it is the heat treating furnace with which cleanliness

was managed.
[0061] For example, in order to disappear or reduce a Grown-in defect effectively, the important thing for which the diffusion furnace of the horizontal type of a heater heating type or a vertical mold may be used, and the **** type wafer heating apparatus of a lamp heating type may be used the heat treatment temperature under sufficient non-oxidizing atmosphere, heat treatment time amount, and the heat treatment temperature and heat treatment time amount under sufficient oxidizing atmosphere which follows it -- securing -- in addition -- and it is carrying out continuously so that the temperature during two heat treatments may not fall too much.
[0062] For that purpose, it is necessary to oxidize 1 minute or more at the temperature of 700-1300 degrees C under an oxidizing atmosphere succeedingly, without cooling the silicon single crystal wafer 5 in temperature of less than 700 degrees C, after performing heat treatment for 1 minute or more at the temperature of 1100-1300 degrees C under the mixed-gas ambient atmosphere of a non-oxidizing gas especially an argon, nitrogen, or an argon and nitrogen.
[0063] When not processing continuously between heat treatment under the mixed-gas ambient atmosphere of a non-oxidizing gas especially an argon, nitrogen, or an argon and nitrogen, and oxidation heat treatments, the wall oxide film of a Grown-in defect re-grows, and it becomes impossible as mentioned above, to disappear or reduce a defect as a result. Therefore, it is desirable to perform heat treatment and oxidation heat treatment of argon atmosphere etc. in succession [before a wafer 5 cools in temperature of less than 700 degrees C], without taking out a wafer 5 from the inside of a furnace. Moreover, heat treatment time amount can be shortened by heat-treating continuously at the same temperature.
[0064] After performing heat treatment under ambient atmospheres, such as mixed gas of an argon, nitrogen, or an argon and nitrogen, in order to do in this way for example, to exhaust a controlled atmosphere, without cooling the temperature in a furnace, to introduce the oxygen gas of desired concentration succeedingly, and what is necessary is just made to perform oxidation heat treatment. In this invention, since heat treatment which dissolves the defective wall oxide film of the first rank is performed under the non-oxidizing gas ambient atmosphere which does not contain hydrogen, such as mixed gas of an argon, nitrogen, or an argon and nitrogen, beyond a lower explosive limit (about 4%), even if it uses the heat treating furnace of a certain marketing from the former, oxidation heat treatment of the next step can be carried out to insurance.
[0065] Moreover, after making a protection oxide film form in the wafer front face which performs heat treatment under non-oxidizing atmospheres, such as mixed gas of an argon, nitrogen, or the argon and nitrogen for dissolving a defective wall oxide film, beforehand, when carrying out, the oxide-film formation heat treatment may be included in the preceding paragraph of heat treatment in which a wall oxide film is dissolved, may be performed continuously, and may completely be beforehand formed by another heat treatment. Moreover, thermal oxidation like the wet oxidation containing the dry oxidation and the steam by the so-called desiccation oxygen is sufficient as formation of this oxide film, and it may be a CVD oxide film by the CVD (Chemical Vapor Deposition) method.
[0066] In addition, in heat treatment under the 2nd step of oxidizing atmosphere shown in drawing 1 (C) and drawing 2 , either the dry oxidation which does not contain a steam in an ambient atmosphere, or the wet oxidation containing a steam can be applied, and effectiveness equivalent as effectiveness of improving the effectiveness and field granularity which pour the silicon between grids into the Grown-in defect which is the essence of this invention can be expected.
[0067] Next, as shown in drawing 1 (D), a lamination SOI wafer is manufactured, using the silicon single crystal wafer with which silicon oxide was formed in the front face manufactured by doing in this way as a bond wafer 1. Since the oxide film 4 formed at the front process is used as BOX of a SOI wafer as shown in drawing 1 (D), simplification of a process is possible. Furthermore, since an oxide film is formed after Ar annealing, it becomes possible to form BOX excellent in membraneous quality. It is made to stick at the base wafer 2 and a room temperature through this BOX, and in order to join together still more firmly, 200 degrees C or more of heat-of-linkage processings of 1000 degrees C - about 1200 degrees C are usually added. Although a silicon single crystal wafer is usually used as a base wafer 2,

insulating substrates (a quartz, sapphire, etc.) may be used depending on an application. Moreover, when a silicon single crystal wafer is used, after forming an oxide film in the base wafer 2, it can also join together.
[0068] After performing heat-of-linkage processing, thin film-ization by the usual grinding, polish, etc. is performed to the bond wafer 1, and the SOI wafer 10 is produced (drawing 1 (E)). In this way, the lamination SOI wafer 10 with which BOX12 which consists of an oxide film 4, and the SOI layer 11 which consists of the low defective layer 3 were formed on the base wafer 2 can be obtained. Since the SOI layer 11 of this SOI wafer 10 consists of the low defective layer 3, defects, such as COP, can make it very few things over all the fields of that depth direction. In addition, gas phase etching called PACE (Plasma Assisted Chemical Etching) in this case can be performed, and thin film-ization of the bond wafer 1 can also be performed (refer to the patent No. 2565617 official report).
[0069] Moreover, in producing a SOI wafer using the ion-implantation exfoliating method (refer to the technique and JP,5-211128,A which are called a smart cut), in the phase which formed the oxide film 4 in the front face of the silicon single crystal wafer 5 by said two-step heat treatment, impregnation of a hydrogen ion or rare gas ion is performed through the oxide film 4, and it considers as the bond wafer 1 and performs association with **-SUUEHA 2. In this case, since it becomes the total variation with which the variation in the ion-implantation depth and the variation of oxide film thickness were doubled, in order to make this as small as possible, as for the variation in the SOI layer membrane thickness produced, it is desirable to make as thin as possible thickness of the oxide film 4 formed in the silicon single crystal wafer 5 used as the bond wafer 1, and to make the absolute value of oxide film variation small. For this reason, as for oxide-film thickness, it is desirable to make it 100nm or less, and in order to fully acquire the defective disappearance effectiveness, it is desirable to be referred to as 20nm or more. In addition, what is necessary is to be the case where oxide-film thickness formed in a bond wafer in this way is set to 100nm or less, to form the oxide film of an insufficiency in a base wafer, and just to combine with it as BOX of a SOI wafer, when the thickness beyond this is needed on a device design.
[0070] Moreover, the bond wafer which exfoliated when producing a SOI wafer by such ion-implantation exfoliating method can be used as a new bond wafer or a base wafer. As mentioned above, the bond wafer after the exfoliation by which the byproduction was carried out in this way has the defect-free field of sufficient depth for the surface, and in the bulk section, since sufficient quantity of an oxygen sludge deposits by heat treatment, it can turn into a good bond wafer or a base wafer.
[0071] In this case, one field of especially the wafer by which a byproduction is carried out by this invention is a stripped plane, and the field of that opposite side is a flat field with the silicon wafer of a basis. Therefore, what is necessary is to add reprocessing, such as grinding and polish, only to a stripped plane side. Therefore, since it is processing of only one side, it is easy, and there are also few the allowances for machining and they end. That is, in slicing from the usual silicon ingot and obtaining a silicon wafer, since both sides are cutting planes, wrapping, an etching process, etc. are indispensable, the allowance for machining will also become [many], but since one side is flat, if grinding and polish of a stripped plane are done on the basis of this, it is sufficient for the exfoliation wafer of this invention, and it can acquire the same flat field as the silicon mirror plane wafer usual by few allowances for machining.
[0072] And if the silicon wafer which reworked the exfoliation wafer in this way and was obtained is reused as the bond wafer of a SOI wafer, or a base wafer, one SOI wafer can be obtained from one silicon wafer on parenchyma, and the utilization factor of the silicon wafer as an ingredient can be improved remarkably.
[0073]
[Example] Although the example and the example of a comparison of this invention are given and being explained concretely hereafter, this invention is not limited to these.
(An example 1, the example 1 of a comparison, example 2 of a comparison) The bond wafer of a lamination SOI wafer was manufactured and the approach of this invention estimated the quality. As a silicon single crystal wafer used as a bond wafer, it is a 8"phiCZ silicon single crystal, and is oxygen density [Oi] =16ppma (JEIDA) between crystal orientation <100> grids, and what was started from the

single crystal which was able to pull up the crystal raising rate as 1.2 mm/min was used. This invention was heat-treated to this wafer. Here, 30% Ar70% of oxygen of mixed gas performed annealing and performed annealing for 20 minutes at the same temperature continuously under an Ar100% ambient atmosphere by 1200 degrees C for 40 minutes using VERTEX3 (DD-813V) by Kokusai Electric Co., Ltd. as an annealing furnace. The formed oxide-film thickness was about 30nm.
[0074] The wafer which performed annealing performed 5-micrometer polish after the oxide-film removal by the fluoric acid solution, and measured the number of COP in a deep field (more than size 0.09micrometer). SurfScan [measurement / COP] by the KLA ten call company SP1 was used. To the silicon single crystal wafer same as a comparison, the wafer (example 1 of a comparison) which performed annealing of H2/1200 degree C /, and 1 hour, and 5 micrometers (example 2 of a comparison) of wafers which performed annealing of Ar / 1200 degrees C / 1 hour were ground, and the number of COP was similarly measured to it. A measurement result is shown in drawing 3 . The number of COP of the wafer of an example 1 is 400 or less pieces among a 8 inch wafer, and serves as a COP consistency of two or less [1.3 //cm] from this drawing 3 . Therefore, it can be said that this approach has effectiveness higher than conventional H2 or conventional Ar annealing about the disappearance effectiveness of a Grown-in defect.
[0075] Moreover, the oxide-film proof-pressure property of a wafer of having performed these 5-micrometer polishes was measured. The result of measurement is shown in drawing 4 and drawing 5 . In addition, the rate of an excellent article of TDDB (Time Dependent Dielectric Breakdown) said here is a rate of an excellent article at the time of using as an excellent article that in which oxide-film pressure-proofing has two or more 5 C/cm under conditions of 2 and stress current value 0.01 A/cm2,100 degree C the gate oxidation thickness of 25nm, and a gate area of 4mm the thing in which oxide-film pressure-proofing has two or more 25 C/cm or the gate oxidation thickness of 25nm, and a gate area of 4mm under 2, stress current value 0.01 A/cm2, and the conditions of a room temperature.
[0076] Moreover, the rate of an excellent article of TZDB (Time Zero Dielectric Breakdown) said here is a rate of an excellent article at the time of using as an excellent article that in which oxide-film pressure-proofing has 8 or more MV/cm the gate oxidation thickness of 25nm, and a gate area of 8mm under 2, judgment current value 1 mA/cm2, and the conditions of a room temperature.
[0077] It turns out that the wafer processed by this approach also in the oxide-film proof-pressure property measurement result from drawing 4 and drawing 5 shows the oxide-film proof-pressure property of having excelled H2 or Ar annealing wafer also in the deep field. When producing the silicon single crystal wafer which turns into a bond wafer using the approach of this invention by the above result, there were few crystal defects, and it turned out that the wafer excellent also in the oxide-film proof-pressure property is obtained. Therefore, if a SOI wafer is produced using such a silicon single crystal wafer, a SOI wafer with few crystal defects will be obtained.
[0078] The SOI wafer which has about 0.1-micrometer SOI layer membrane thickness by the ion-implantation exfoliating method was produced using three kinds of bond wafers produced on condition that the above. The production conditions are as follows.
1) hydrogen ion impregnation condition: -- H+ ion, an impregnation energy 30KeV2 exfoliation heat treatment condition:oxidizing atmosphere, 500 degrees C, 30-minute heat-of-linkage [3] processing condition:nitrogen-gas-atmosphere mind (minute amount oxygen content), 1200 degrees C, and 5 base wafer oxide-film [with 120 minute touch / 4 / polish (minute amount polish on the front face of SOI)]: -- 300nm [0079] COP of the produced SOI wafer was observed with HF dip method. Although HF will reach BOX through this, an oxide film will be etched and an etch pit will be formed if there is a defect which penetrates a SOI layer when the SOI wafer which has the above thin SOI layers is immersed in an HF50% water solution with HF dip method, it is the approach of evaluating COP of a wafer, by spacing a thin SOI layer and observing this etch pit with an optical microscope. A measurement result is shown in Table 1.
[0080]
[Table 1]

	熱処理雰囲気	COP密度(個/cm²)
実施例1	Ar+Ar/O_2	0.2
比較例1	H_2のみ	1.8
比較例2	Arのみ	1.9

[0081] The SOI wafer of an example is understood that there is very little COP which penetrates a SOI layer compared with the SOI wafer which has given only H2 annealing or Ar annealing to the conventional bond wafer from Table 1. Moreover, as mentioned above, the SOI wafer of this example 1 is crossed to all the fields of the depth direction of that SOI layer, and since COP 0.09 micrometers or more is two or less [1.3 //cm], magnitude can use it as the SOI wafer of high quality extremely.
[0082] Moreover, when producing the SOI wafer of an example 1, the level difference of about 0.2-0.3 micrometers remained in the periphery of the bond wafer after the exfoliation by which the byproduction was carried out, but after removing a surface oxide film, the good mirror plane which can remove a level difference only by grinding about 1 micrometer of stripped planes, and the oxygen sludge has not exposed was acquired. Therefore, even if it used this wafer as a new bond wafer or a base wafer, it has checked that there was no trouble in lamination.
[0083] (An example 1, an example 2, example 3) Using three kinds of silicon single crystal wafers, by the approach of this invention, the bond wafer of a lamination SOI wafer was manufactured and the quality was compared. Although other conditions are the same as an example 1 as the wafer cut down from the single crystal which was able to speed up and pull up the crystal raising rate to 1.9 mm/min although other conditions were the same as the example 1 as the wafer which used the used silicon single crystal wafer in the example 1, and an example 2, and an example 3, they are three kinds of silicon wafers of the wafer cut down from the single crystal which added nitrogen three times 1014 atoms/cm. 30% Ar70% of oxygen of mixed gas performed annealing and performed annealing to these wafers for 20 minutes at the same temperature continuously under the Ar100% ambient atmosphere by 1200 degrees C for 40 minutes. 5-micrometer polish was performed after the oxide-film removal by HF solution, and the number of COP in a deep field (>=0.09micrometer) was measured. A result is shown in drawing 6 .
[0084] Most, little crystal of COP is a wafer which consists of the crystal which doped nitrogen, and serves as order of the wafer which consists of the crystal pulled up at high speed, and the wafer which consists of the crystal usually pulled up at the rate from this drawing 6 . Therefore, by this approach, a bond wafer with still few Grown-in defects is producible by using the crystal and nitrogen dope crystal which were pulled up at high speed. Moreover, if a crystal is pulled up at high speed, the time amount of crystal raising can be shortened and improvement in a throughput can be aimed at. Moreover, also about the bond wafer produced on the three above-mentioned kinds of conditions, the SOI wafer was produced by the same approach as an example 1, and COP was evaluated. The result is shown in Table 2.
[0085]
[Table 2]

	ボンドウェーハ	COP密度(個/cm²)
実施例1	通常引上げ速度、窒素ドープなし	0.2
実施例2	高速引上げ速度、窒素ドープなし	0.1
実施例3	通常引上げ速度、窒素ドープあり	0.01

[0086] As shown in Table 2, the COP consistency of the SOI wafer using the silicon single crystal wafer which consists of the crystal pulled up at high speed is 1/2 of a SOI wafer which used the usual silicon single crystal wafer, and although the silicon single crystal wafer which consists of the crystal which doped nitrogen was used, the COP consistency has dropped to 1/20 of the usual thing. Therefore, a SOI wafer with a still better SOI layer can be obtained by using the crystal and nitrogen dope crystal which were pulled up at high speed.
[0087] (An example 4, the example 3 of a comparison, example 4 of a comparison) After performing Ar100%1200 degree-C annealing to the same silicon single crystal wafer as what was used in the example 1 for 40 minutes, the line formed 1.0 micrometers of oxide films for oxidation in the ambient atmosphere which contains a steam continuously at 1150 degrees C for 240 minutes. This wafer was

used as the bond wafer and lamination SOI whose SOI layer is 5 micrometers and whose BOX layer is 1 micrometer was produced by the usual grinding and polish technique. MPV-SP made from Leitz was used for oxide-film thickness measurement.
[0088] Once cooling to a room temperature to this wafer, the wafer (example 3 of a comparison) which performed annealing as a comparison for H2/1200 degree C /, and 1 hour, and the wafer (example 4 of a comparison) which performed annealing for Ar / 1200 degrees C / 1 hour, the oxide-film proof-pressure property of the SOI wafer produced from the wafer which added only oxidation heat treatment (it is 240 minutes at 1150 degrees C about oxidation in the ambient atmosphere containing a steam) was compared. The used wafer and the oxide-film proof-pressure Measuring condition are the same as an example 1.
[0089] A result is indicated to be drawing 7 to 8. Consequently, it turns out that the oxide-film pressure-proofing to which the wafer which added heat treatment of this invention was superior as compared with the wafer with which TZDB and TDDB only added oxidation heat treatment even if the thickness of the SOI layer from which effectiveness was seldom acquired by the conventional annealing approach was the thing of the thickness exceeding 0.5 micrometers is shown.
[0090] In addition, this invention is not limited to the above-mentioned operation gestalt. The above-mentioned operation gestalt is instantiation, and no matter it may be what thing which has the same configuration substantially with the technical thought indicated by the claim of this invention, and does the same operation effectiveness so, it is included by the technical range of this invention.
[0091] for example, MCZ which it faces raising a silicon single crystal rod irrespective of the existence of the dope of nitrogen, and it is not asked whether the magnetic field is impressed to melt, and impresses the so-called magnetic field to the Czochrlski method of this invention with the Czochrlski method in this invention -- law is also included.
[0092] Moreover, elevated-temperature heat treatment under the non-oxidizing atmosphere which is the substantial part of this invention, and heat treatment under an oxidizing atmosphere are applicable in any processes in a wafer processing process. For example, heat treatment of this invention is applicable after the chemical etching process after wafer cutting, the rough polish process which is a subsequent process, or the last polish process etc.
[0093] Moreover, although the above-mentioned operation gestalt explained heat treatment under the non-oxidizing gas ambient atmosphere of this invention focusing on the case where an argon or nitrogen gas is used An ambient atmosphere is not necessarily what is limited only to an argon or nitrogen gas. It can apply, if it is the gas which made these gas mix the hydrogen of the minute amount below a lower explosive limit, and gas which has the same effectiveness as an argon by rare gas, such as helium, neon, a krypton, and a xenon, and it is contained in the range of this invention. Moreover, about heat treatment under the mixed-gas ambient atmosphere of an argon and nitrogen, rare gas other than an argon is applicable similarly.
[0094]
[Effect of the Invention] It is possible to disappear a void defect to a deep field more efficient than a conventional method, and the SOI layer of the outstanding quality can be formed. Moreover, since heat treatment of a non-oxidizing quality ambient atmosphere and heat treatment of an oxidizing atmosphere can be processed in same batch and it can also heat-treat, without not leading to a cost rise and using hydrogen at all, without the routing counter in a SOI making process increasing, there is also neither the contamination from the furnace resulting from hydrogen nor the danger of explosion, and heat treatment is possible. Moreover, since CZ wafer is used, it can respond also to the diameter of macrostomia 300mm or more.

[Translation done.]

* NOTICES *

TECHNICAL FIELD

[Field of the Invention] This invention relates to the manufacture approach of a lamination SOI wafer with very few crystal defects near a front face and the front face, and a lamination SOI wafer.

[Translation done.]

* NOTICES *

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3.In the drawings, any words are not translated.

PRIOR ART

[Description of the Prior Art] SOI (Silicon On Insulator) has an embedding oxide film (BOX:BuriedOXide) as an insulator layer directly under [used as a device production field] a silicon layer, and is expected as a silicon ingredient of power saving and a high-speed device. Although there is a lamination method as one of the SOI wafer manufacture approaches, this is the approach of thin-film-izing lamination and a bond wafer for two silicon single crystal wafers through an oxide film as a bond wafer (substrate used as the SOI layer by which a device is produced), and a base wafer (substrate which supports a SOI layer), and forming SOI structure. Although this approach is excellent in the crystallinity of a SOI layer and has the advantage that the insulation of BOX is high, on the other hand, the fault that the quality of a SOI layer is greatly influenced by the quality of this bond wafer also exists.
[0003] In the silicon wafer produced with the Czochrlski method (CZ process), it is specifically known that minute crystal defects (Grown-in defect), such as COP (Crystal Originated Particles) which is a void mold defect, exist, and these have a bad influence on device properties including an oxide film proof-pressure property. In order to solve this problem, it is known by using for CZ wafer the wafer which gave annealing in a hydrogen ambient atmosphere, and the epitaxial wafer in which the epitaxial layer was formed, as a substrate used for a bond wafer that the defect observed will decrease (refer to JP,9-22993,A and JP,9-260619,A). However, by these approaches, two heat treatments, heat treatment of hydrogen annealing or epitaxial growth and oxide-film formation heat treatment for forming the embedding oxide film of a SOI wafer, are needed, and the problem of the fall of the increase and the throughput of cost etc. exists.
[0004] Moreover, since in the case of an epitaxial wafer Hayes (field dry area) occurs on an epitaxial layer front face, or the projection called the mound is formed in it and these cause ill cohesion of strands at the time of lamination, the time and effort of joining together once it grinds an epitaxial layer front face may be needed.
[0005] That a crystal defect decreases by performing hydrogen annealing on the other hand In the SOI front face at the time of producing the SOI wafer which has the thickness beyond this, since it is restricted to the pole surface layer (about 0.5 micrometers) If the measures of adding hydrogen annealing further were not taken after producing the SOI wafer since the field where the crystal defect is not reduced would be exposed, the crystal defect covering the whole SOI layer was not able to be reduced. Furthermore, annealing using hydrogen always etches a quartz tube, the boat made from SiC, etc., and contamination of a metal impurity etc. may take place from there.
[0006] Furthermore, although insurance needed to be secured by take out a wafer after heat-treat in a hydrogen ambient atmosphere, and nitrogen gas permuted the inside of a heat treating furnace, the oxygen and the moisture of a minute amount which be contain in nitrogen gas etched the wafer front face locally, and worsened surface roughness, such as Hayes, and the trouble of become the cause that these association at the time of lamination be poor also had them.
[0007] Moreover, by recently, if a crystal is pulled up controlling strictly the growth rate at the time of single crystal growth, and the temperature gradient of a solid-liquid interface by the CZ process, it is reported that CZ wafer with which the Grown-in defect was reduced very much is made. Although it can

guess easily that the defect of a SOI layer can produce few SOI wafers if such a wafer is used for a bond wafer, pulling up a crystal on such very severe growth conditions actually leads to the fall of a manufacture yield with a natural thing, and it brings about a cost rise great as a result.

[0008] On the other hand, although a COP defect which is looked at by CZ single crystal is free, the diameter of 150mm of an FZ crystal producible on current commercial level is a limit, and although no less than 200mm is possible, on experiment level, it is not [to the wafer of diameters of macrostomia, such as 300mm of future, and 400mm,] in prospect, if it is the single crystal produced by the FZ method.

[Translation done.]

EFFECT OF THE INVENTION

[Effect of the Invention] It is possible to disappear a void defect to a deep field more efficient than a conventional method, and the SOI layer of the outstanding quality can be formed. Moreover, since heat treatment of a non-oxidizing quality ambient atmosphere and heat treatment of an oxidizing atmosphere can be processed in same batch and it can also heat-treat, without not leading to a cost rise and using hydrogen at all, without the routing counter in a SOI making process increasing, there is also neither the contamination from the furnace resulting from hydrogen nor the danger of explosion, and heat treatment is possible. Moreover, since CZ wafer is used, it can respond also to the diameter of macrostomia 300mm or more.

[Translation done.]

TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] This invention sets it as the main purpose to obtain the SOI wafer which has the SOI layer of high quality with few crystal defects by the sex from Takao, the high yield, and low cost by having been made in view of such a trouble and using the wafer which decreases or extinguished effectively the Grown-in defect of the surface section of the silicon single crystal wafer produced by the CZ process by heat treatment as a bond wafer of a lamination wafer.

[Translation done.]

* NOTICES *

EXAMPLE

[Example] Although the example and the example of a comparison of this invention are given and being explained concretely hereafter, this invention is not limited to these.
(An example 1, the example 1 of a comparison, example 2 of a comparison) The bond wafer of a lamination SOI wafer was manufactured and the approach of this invention estimated the quality. As a silicon single crystal wafer used as a bond wafer, it is a 8"phiCZ silicon single crystal, and is oxygen density [Oi] =16ppma (JEIDA) between crystal orientation <100> grids, and what was started from the single crystal which was able to pull up the crystal raising rate as 1.2 mm/min was used. This invention was heat-treated to this wafer. Here, 30% Ar70% of oxygen of mixed gas performed annealing and performed annealing for 20 minutes at the same temperature continuously under an Ar100% ambient atmosphere by 1200 degrees C for 40 minutes using VERTEX3 (DD-813V) by Kokusai Electric Co., Ltd. as an annealing furnace. The formed oxide-film thickness was about 30nm.
[0074] The wafer which performed annealing performed 5-micrometer polish after the oxide-film removal by the fluoric acid solution, and measured the number of COP in a deep field (more than size 0.09micrometer). SurfScan [measurement / COP] by the KLA ten call company SP1 was used. To the silicon single crystal wafer same as a comparison, the wafer (example 1 of a comparison) which performed annealing of H2/1200 degree C /, and 1 hour, and 5 micrometers (example 2 of a comparison) of wafers which performed annealing of Ar / 1200 degrees C / 1 hour were ground, and the number of COP was similarly measured to it. A measurement result is shown in drawing 3 . The number of COP of the wafer of an example 1 is 400 or less pieces among a 8 inch wafer, and serves as a COP consistency of two or less [1.3 //cm] from this drawing 3 . Therefore, it can be said that this approach has effectiveness higher than conventional H2 or conventional Ar annealing about the disappearance effectiveness of a Grown-in defect.
[0075] Moreover, the oxide-film proof-pressure property of a wafer of having performed these 5-micrometer polishes was measured. The result of measurement is shown in drawing 4 and drawing 5 . In addition, the rate of an excellent article of TDDB (Time Dependent Dielectric Breakdown) said here is a rate of an excellent article at the time of using as an excellent article that in which oxide-film pressure-proofing has two or more 5 C/cm under conditions of 2 and stress current value 0.01 A/cm2,100 degree C the gate oxidation thickness of 25nm, and a gate area of 4mm the thing in which oxide-film pressure-proofing has two or more 25 C/cm or the gate oxidation thickness of 25nm, and a gate area of 4mm under 2, stress current value 0.01 A/cm2, and the conditions of a room temperature.
[0076] Moreover, the rate of an excellent article of TZDB (Time Zero Dielectric Breakdown) said here is a rate of an excellent article at the time of using as an excellent article that in which oxide-film pressure-proofing has 8 or more MV/cm the gate oxidation thickness of 25nm, and a gate area of 8mm under 2, judgment current value 1 mA/cm2, and the conditions of a room temperature.
[0077] It turns out that the wafer processed by this approach also in the oxide-film proof-pressure property measurement result from drawing 4 and drawing 5 shows the oxide-film proof-pressure property of having excelled H2 or Ar annealing wafer also in the deep field. When producing the silicon single crystal wafer which turns into a bond wafer using the approach of this invention by the above

result, there were few crystal defects, and it turned out that the wafer excellent also in the oxide-film proof-pressure property is obtained. Therefore, if a SOI wafer is produced using such a silicon single crystal wafer, a SOI wafer with few crystal defects will be obtained.

[0078] The SOI wafer which has about 0.1-micrometer SOI layer membrane thickness by the ion-implantation exfoliating method was produced using three kinds of bond wafers produced on condition that the above. The production conditions are as follows.

1) hydrogen ion impregnation condition: -- H+ ion, an impregnation energy 30KeV2 exfoliation heat treatment condition:oxidizing atmosphere, 500 degrees C, 30-minute heat-of-linkage [3] processing condition:nitrogen-gas-atmosphere mind (minute amount oxygen content), 1200 degrees C, and 5 base wafer oxide-film [with 120 minute touch / 4 / polish (minute amount polish on the front face of SOI)]: -- 300nm [0079] COP of the produced SOI wafer was observed with HF dip method. Although HF will reach BOX through this, an oxide film will be etched and an etch pit will be formed if there is a defect which penetrates a SOI layer when the SOI wafer which has the above thin SOI layers is immersed in an HF50% water solution with HF dip method, it is the approach of evaluating COP of a wafer, by spacing a thin SOI layer and observing this etch pit with an optical microscope. A measurement result is shown in Table 1.

[0080]

[Table 1]

	熱処理雰囲気	COP密度(個／cm^2)
実施例1	Ar+Ar／O_2	·0. 2
比較例1	H_2のみ	1. 8
比較例2	Arのみ	1. 9

[0081] The SOI wafer of an example is understood that there is very little COP which penetrates a SOI layer compared with the SOI wafer which has given only H2 annealing or Ar annealing to the conventional bond wafer from Table 1. Moreover, as mentioned above, the SOI wafer of this example 1 is crossed to all the fields of the depth direction of that SOI layer, and since COP 0.09 micrometers or more is two or less [1.3 //cm], magnitude can use it as the SOI wafer of high quality extremely.

[0082] Moreover, when producing the SOI wafer of an example 1, the level difference of about 0.2-0.3 micrometers remained in the periphery of the bond wafer after the exfoliation by which the byproduction was carried out, but after removing a surface oxide film, the good mirror plane which can remove a level difference only by grinding about 1 micrometer of stripped planes, and the oxygen sludge has not exposed was acquired. Therefore, even if it used this wafer as a new bond wafer or a base wafer, it has checked that there was no trouble in lamination.

[0083] (An example 1, an example 2, example 3) Using three kinds of silicon single crystal wafers, by the approach of this invention, the bond wafer of a lamination SOI wafer was manufactured and the quality was compared. Although other conditions are the same as an example 1 as the wafer cut down from the single crystal which was able to speed up and pull up the crystal raising rate to 1.9 mm/min although other conditions were the same as the example 1 as the wafer which used the used silicon single crystal wafer in the example 1, and an example 2, and an example 3, they are three kinds of silicon wafers of the wafer cut down from the single crystal which added nitrogen three times 1014 atoms/cm. 30% Ar70% of oxygen of mixed gas performed annealing and performed annealing to these wafers for 20 minutes at the same temperature continuously under the Ar100% ambient atmosphere by 1200 degrees C for 40 minutes. 5-micrometer polish was performed after the oxide-film removal by HF solution, and the number of COP in a deep field (>=0.09micrometer) was measured. A result is shown in drawing 6 .

[0084] Most, little crystal of COP is a wafer which consists of the crystal which doped nitrogen, and serves as order of the wafer which consists of the crystal pulled up at high speed, and the wafer which consists of the crystal usually pulled up at the rate from this drawing 6 . Therefore, by this approach, a bond wafer with still few Grown-in defects is producible by using the crystal and nitrogen dope crystal which were pulled up at high speed. Moreover, if a crystal is pulled up at high speed, the time amount of

crystal raising can be shortened and improvement in a throughput can be aimed at. Moreover, also about the bond wafer produced on the three above-mentioned kinds of conditions, the SOI wafer was produced by the same approach as an example 1, and COP was evaluated. The result is shown in Table 2.
[0085]
[Table 2]

	ボンドウェーハ	COP密度（個／cm²）
実施例1	通常引上げ速度、窒素ドープなし	0.2
実施例2	高速引上げ速度、窒素ドープなし	0.1
実施例3	通常引上げ速度、窒素ドープあり	0.01

[0086] As shown in Table 2, the COP consistency of the SOI wafer using the silicon single crystal wafer which consists of the crystal pulled up at high speed is 1/2 of a SOI wafer which used the usual silicon single crystal wafer, and although the silicon single crystal wafer which consists of the crystal which doped nitrogen was used, the COP consistency has dropped to 1/20 of the usual thing. Therefore, a SOI wafer with a still better SOI layer can be obtained by using the crystal and nitrogen dope crystal which were pulled up at high speed.
[0087] (An example 4, the example 3 of a comparison, example 4 of a comparison) After performing Ar100%1200 degree-C annealing to the same silicon single crystal wafer as what was used in the example 1 for 40 minutes, the line formed 1.0 micrometers of oxide films for oxidation in the ambient atmosphere which contains a steam continuously at 1150 degrees C for 240 minutes. This wafer was used as the bond wafer and lamination SOI whose SOI layer is 5 micrometers and whose BOX layer is 1 micrometer was produced by the usual grinding and polish technique. MPV-SP made from Leitz was used for oxide-film thickness measurement.
[0088] Once cooling to a room temperature to this wafer, the wafer (example 3 of a comparison) which performed annealing as a comparison for H2/1200 degree C /, and 1 hour, and the wafer (example 4 of a comparison) which performed annealing for Ar / 1200 degrees C / 1 hour, the oxide-film proof-pressure property of the SOI wafer produced from the wafer which added only oxidation heat treatment (it is 240 minutes at 1150 degrees C about oxidation in the ambient atmosphere containing a steam) was compared. The used wafer and the oxide-film proof-pressure Measuring condition are the same as an example 1.
[0089] A result is indicated to be drawing 7 to 8. Consequently, it turns out that the oxide-film pressure-proofing to which the wafer which added heat treatment of this invention was superior as compared with the wafer with which TZDB and TDDB only added oxidation heat treatment even if the thickness of the SOI layer from which effectiveness was seldom acquired by the conventional annealing approach was the thing of the thickness exceeding 0.5 micrometers is shown.
[0090] In addition, this invention is not limited to the above-mentioned operation gestalt. The above-mentioned operation gestalt is instantiation, and no matter it may be what thing which has the same configuration substantially with the technical thought indicated by the claim of this invention, and does the same operation effectiveness so, it is included by the technical range of this invention.
[0091] for example, MCZ which it faces raising a silicon single crystal rod irrespective of the existence of the dope of nitrogen, and it is not asked whether the magnetic field is impressed to melt, and impresses the so-called magnetic field to the Czochrlski method of this invention with the Czochrlski method in this invention -- law is also included.
[0092] Moreover, elevated-temperature heat treatment under the non-oxidizing atmosphere which is the substantial part of this invention, and heat treatment under an oxidizing atmosphere are applicable in any processes in a wafer processing process. For example, heat treatment of this invention is applicable after the chemical etching process after wafer cutting, the rough polish process which is a subsequent process, or the last polish process etc.
[0093] Moreover, although the above-mentioned operation gestalt explained heat treatment under the non-oxidizing gas ambient atmosphere of this invention focusing on the case where an argon or nitrogen gas is used An ambient atmosphere is not necessarily what is limited only to an argon or nitrogen gas. It

can apply, if it is the gas which made these gas mix the hydrogen of the minute amount below a lower explosive limit, and gas which has the same effectiveness as an argon by rare gas, such as helium, neon, a krypton, and a xenon, and it is contained in the range of this invention. Moreover, about heat treatment under the mixed-gas ambient atmosphere of an argon and nitrogen, rare gas other than an argon is applicable similarly.

[Translation done.]

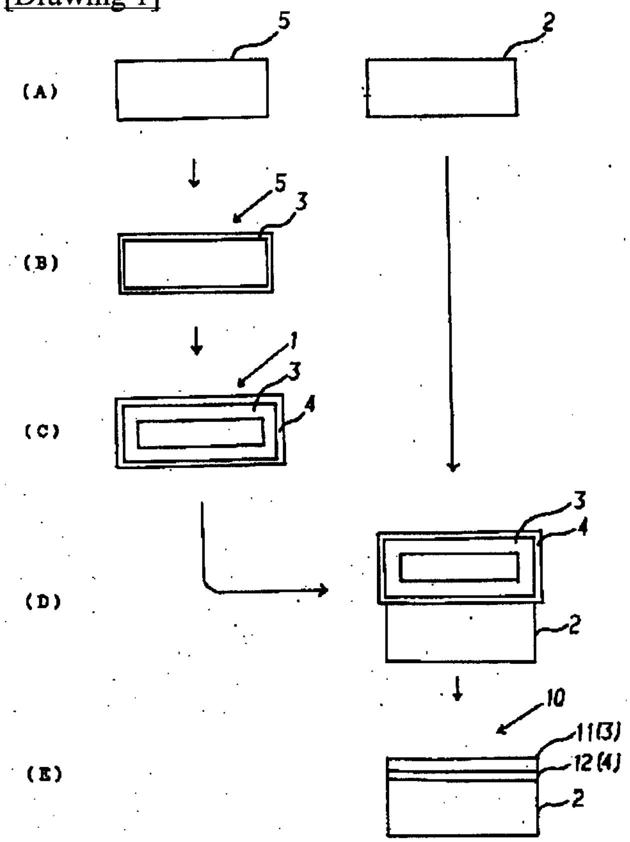
DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] (A) - (E) is the flow Fig. having shown an example like the manufacture line of the lamination SOI wafer of this invention.
[Drawing 2] It is drawing having shown the outline of heat treatment added to the silicon single crystal wafer which turns into a bond wafer in front of lamination.
[Drawing 3] In an example 1, the example 1 of a comparison, and the example 2 of a comparison, as a result of measuring the number of COP of the wafer after heat treatment, it is a Fig.
[Drawing 4] In an example 1, the example 1 of a comparison, and the example 2 of a comparison, it is drawing having shown the rate of an excellent article of TZDB of the wafer after heat treatment.
[Drawing 5] In an example 1, the example 1 of a comparison, and the example 2 of a comparison, it is drawing having shown the rate of an excellent article of TDDB of the wafer after heat treatment.
[Drawing 6] In an example 1 thru/or an example 3, as a result of measuring the number of COP on the front face of a wafer after heat treatment, it is a Fig.
[Drawing 7] In an example 4, it is drawing having shown the rate of a TZDB excellent article of a SOI wafer.
[Drawing 8] In an example 4, it is drawing having shown the rate of a TDDB excellent article of a SOI wafer.
[Drawing 9] (a) is drawing having shown the relation between the oxygen density in an annealing ambient atmosphere, and the number of COP, and (b) is drawing having shown the relation of the oxide-film thickness and the number of COP which were formed of annealing.
[Drawing 10] It is drawing which repeated and gave each of heat treatment of this invention, and the conventional heat treatment by the separate tube, and compared transition of the contamination level by the metal impurity in the wafer for every heat treatment.
[Description of Notations]
1 -- Bond wafer 2 -- Base wafer 3 -- Low defective layer 4 [-- SOI wafer / 11 -- SOI layer 12 -- BOX.] -- An oxide film, 5 -- A silicon single crystal wafer, 10

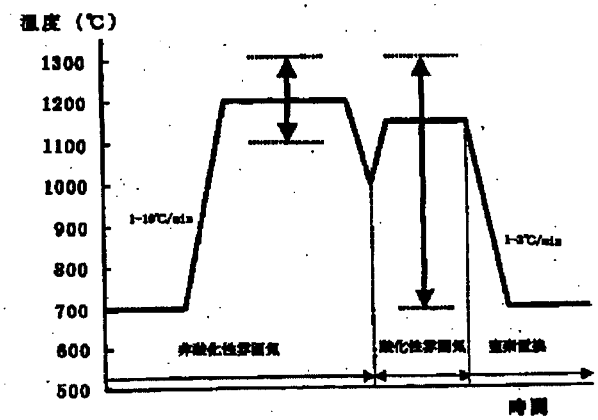
[Translation done.]

DRAWINGS

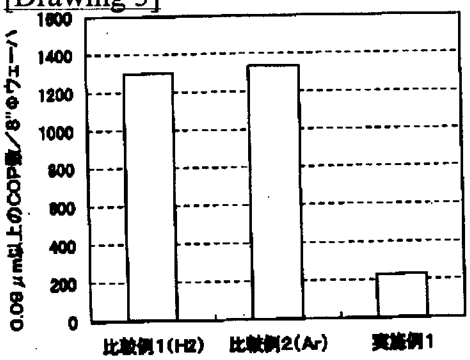
[Drawing 1]



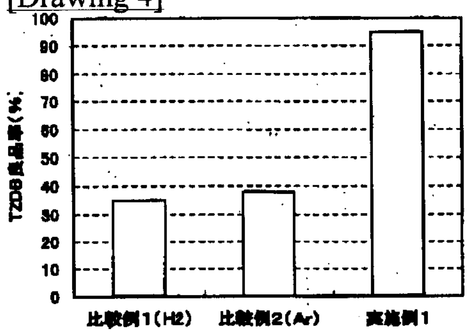
[Drawing 2]



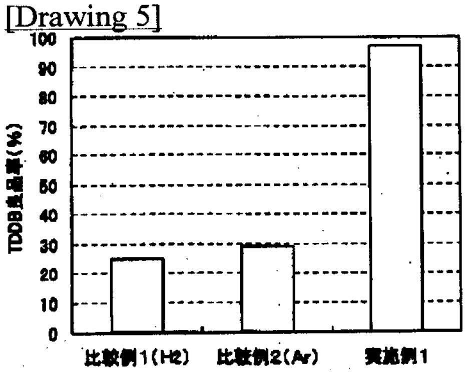
[Drawing 3]



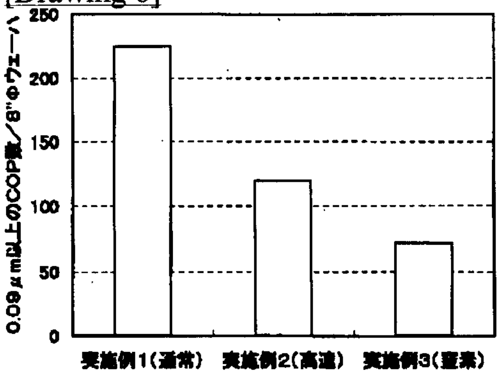
[Drawing 4]



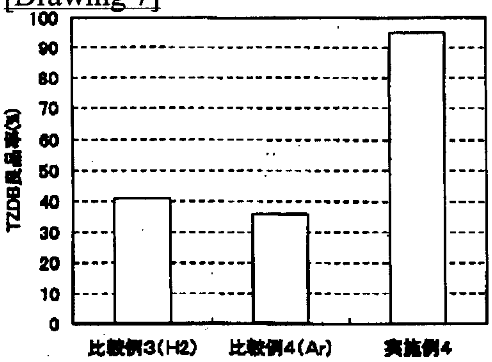
[Drawing 5]



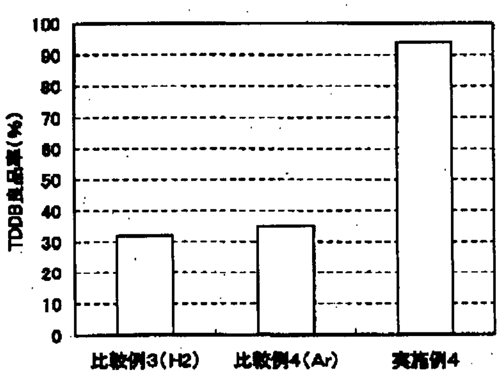
[Drawing 6]



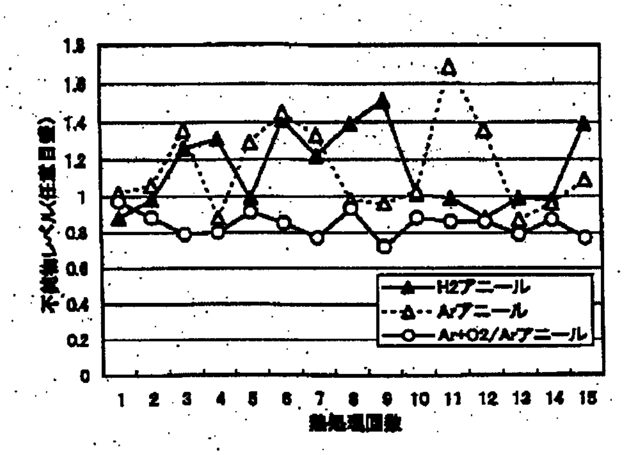
[Drawing 7]



[Drawing 8]

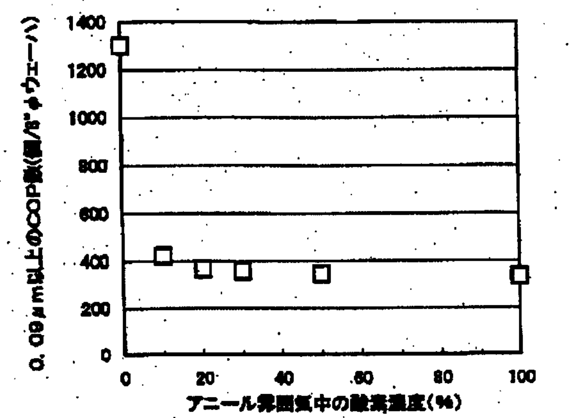


[Drawing 10]

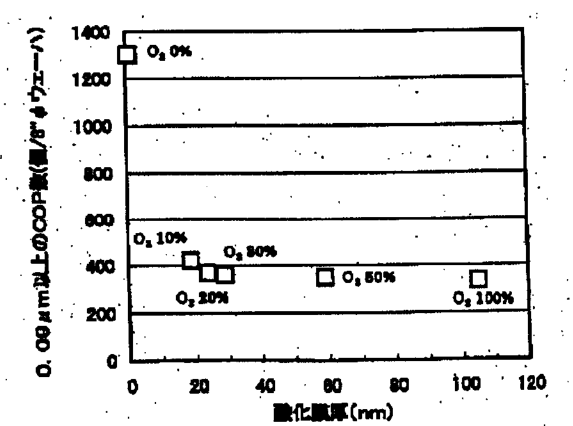


[Drawing 9]

(a)



(b)



[Translation done.]

WRITTEN AMENDMENT

-- [a procedure revision]
[Filing Date] August 23, Heisei 12 (2000. 8.23)
[Procedure amendment 1]
[Document to be Amended] Specification
[Item(s) to be Amended] 0044
[Method of Amendment] Modification
[Proposed Amendment]
[0044] argon 100% -- after annealing for 20 minutes by the mixed gas (oxygen densities 0, 10, and 20, 30 or 50,100%) of six kinds of argons with which 1200 degrees C of oxygen densities differ under an ambient atmosphere after annealing for 40 minutes, and desiccation oxygen, the result of having ground 5 micrometers of front faces of a wafer, and having measured COP 0.09 micrometers or more was shown in drawing 9 (a) and (b), respectively. The reason ground 5 micrometers is for observing the disappearance effectiveness of COP in the wafer surface section. In drawing 9 (a), the relation between the oxygen density in an annealing ambient atmosphere and the number of COP is shown, and the relation of the oxide-film thickness and the number of COP which were formed of annealing is shown in drawing 9 (b) at it. The result of drawing 9 shows that effectiveness equivalent to 100% (about 100nm of oxide-film thickness) of desiccation oxygen will be acquired if the desiccation oxygen density in a mixed-gas ambient atmosphere is 20nm or more of oxide-film thickness formed at least about 10%.
[Procedure amendment 2]
[Document to be Amended] Specification
[Item(s) to be Amended] 0045
[Method of Amendment] Modification
[Proposed Amendment]
[0045] Furthermore, by heat-treating in an oxidizing quality ambient atmosphere, after heat-treating under a non-oxidizing quality ambient atmosphere showed that there was effectiveness which prevents the contamination to the wafer from a tube or a boat to the minimum. drawing 10 -- argon 100% -- under an ambient atmosphere, each of heat treatment which anneals for 20 minutes, and heat treatment which anneals for 60 minutes 1200 degrees C at 100% [of hydrogen] and argon 100% is repeated and heat-treated by the separate tube by the mixed gas (30% of oxygen densities) of an argon and desiccation oxygen, and 1200 degrees C of transitions of the contamination level by the metal impurity in the wafer for every heat treatment are compared, after annealing for 40 minutes. Measurement of contamination level used SPV (Surface Photo Voltage) (trade name: wafer contamination monitor system) by the Semiconductor Diagnostics Inc. (SDI) company.

[Translation done.]